SME, manufacturing, design, CAD, ERP

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CONDITIONS OF MANUFACTURING IN CONTEMPORARY SMALL AND MEDIUM ENTERPRICES

Abstract

In accordance with the requirements of the modern market, small and medium-sized enterprises (SMEs) need to offer a wide range of products tailored to the specific and individual requirements. The article presents the conditions of production using modern computer techniques. Presented solutions are used in modern practice.

1. INTRODUCTION

Mass production tendency has turned into mass customization tendency [17, 27, 33]. In the past the fundamental objectives for most companies were to produce as cheaply and efficiently as possible and to reach as large a customer group as possible with the same product (mass production philosophy). The customer orientation is one of the most essential strategies for every manufacturer. Previously the primary source of competitive advantage for manufacturing companies in many industries was related to price. Therefore, all manufacturing strategies were driven by attempts to reduce the cost of the product. Technological advances, in manufacturing as well as in information, have provided the impetus for change in many paradigms, including customer expectations. Customers have become more demanding and want products that can meet their specific individual requirements. Producing customized products at a low cost, which seemingly is a paradox, is the purpose of many enterprises. The production cycle consists of, among others: the processing time and setup time.

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Despite using modern management techniques e.g. SMED (Single Minute Exchange of Die) technique, in the conditions of unit production in SME, total setup time is still significant.

For high-variety production the cumulative amount of setup time results from the number of changeovers [1]. To shorten the production time and reduce costs the methods of group technology have been used for many years [15]. Despite having many input data from this kind of information systems area of organization of the production process is still supported at insufficient level. The manufacturing system should be supported by efficient IT tools targeted at the possibilities of implementation in small and medium enterprices. To manufacture in efficient way, expert system and methods, which enable quick identification of situation with a crucial impact on the production are needed [3, 5, 12, 16]. Fulfilling customer needs, results in production by unit and small batch process. Enterprises, which manufacture in this conditions have at their disposal modern and universal machinery equipment. For high-variety production the cumulative amount of setup time results from the number of changeovers. In studied SME enterprises proportion between changovers time and processing time is high and it is from several to over a dozen percent of processing time [18, 24].

Research based on real data of enterprises, which use ERP systems in production managment, have induced author to develop method of changeovers time reduction by dynamic grouping and scheduling tasks of operating production plan. Above article presents a problem of optimization of manufacturing using element's grouping techniques with dynamic classification of machine elements (at the level of operation of manufacturing process). Concept of classification refers to the issues connected with group technology [25, 23]. In order to reduce labor intensity of this method data needed to establish "similarity" has been taken from ERP system, using information which has been introduced "on another occasion". Above research has been applied in production practice.

Success of many enterprises, which work in mass production system and use economic effect of scale production slowely is a thing of the past. IT systems focused on management in big companies start to to be interested in manufacturing systems in smaller enterprises. There are many enterprices, generally small and medium manufacturing in unit and small batch production, for which it is necessary to develop optimal methods of production management taking into account the flexible production requirements, matched to the time-varying customer's demand [28, 2, 19, 21].

An example of flow processes in small and batch production is shown in Fig. 1.

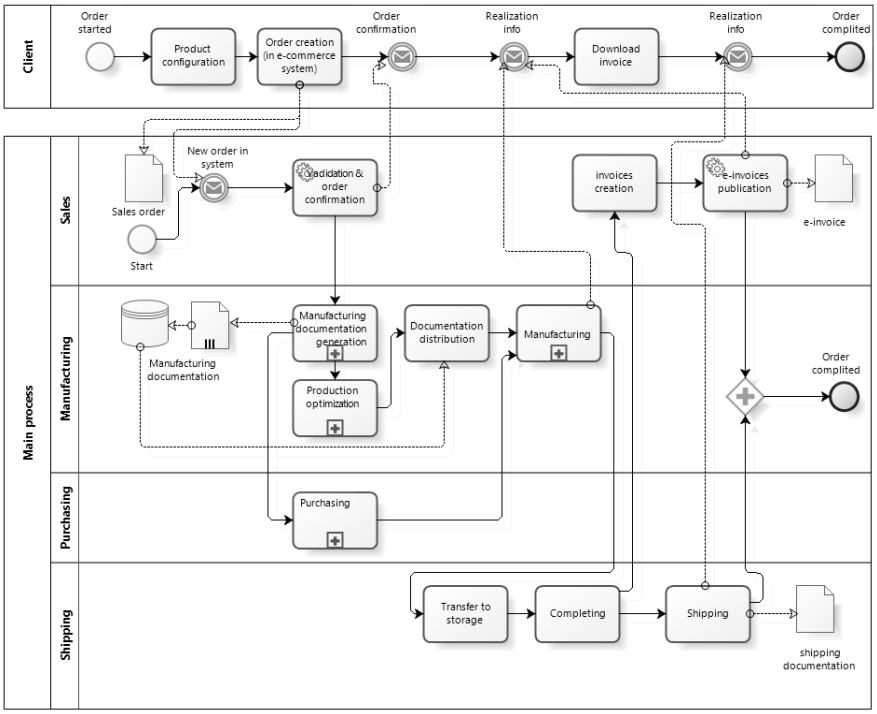

Fig. 1. Processes Flow for the unit and small batch production [source: own study]

For this purpose, it is necessary to use appropriate methodology of scheduling production tasks and IT system, which have functionality for efficient planning and controlling realization of production processes. To be able to manage production efficiently, system and methods, which enable quick identification of situation having big influence on manufacturing are required. Suitable reaction to threats of deadlines or budget, continuous improvement of organization of the production process are still challenge for IT systems in SME. Enterprises to adapt to conditions of modern market invest in modern, universal machines park, which is able to fulfil changeable and unpredictable requisition. Presented method of production management support with using dynamic tasks classification can be one of the elements in optimization of high-variety production in SME [2, 29, 22].

2. DESIGNING STEPS OF THE PRODUCTION PROCESS

Today, manufacturing is complex activity, connecting people, who follow different professions, with using different machines, equipment and tools, which are in varying degrees automated, including computers and robots. This process consists in appropriate utilization of resources: materials, energy of capital and people and it leads to manufacture products from raw materials according to well-prepared plan [7, 35, 4].

Designing of manufacturing process consists of several elements:

- structural design, which aims at development of shape and geometric features of products fullfiling human needs,
- materials design, in order to ensure necessary durability of a product or its elements made from engineering materials with required physico-chemical and technological features ,
- manufacturing process design, which enable giving the required geometric features and property to particular elements of the product, and also their proper cooperation after assembly, taking into account the volume of production, the level of automation and computer support, and at the lowest cost of this product,
- organization of manufacturing process design.

Number of factors and criterions, which are necessary to properly design the product, prepare and organise production connected with launching a product needs continuous development, and above all implementation in production practice modern aided design systems, manufacturing and organization of production process. It means implementation in area of engineering design of computer systems CAx (CAD, CAM, CAP, CAPP), management of product data and life cycle of products PDM, PLM, PLM II also production using manufacturing executive system (MES), enterprise resource planning system (MRPII/ERP/ERPII) and supply chain management system (SCM) [4, 13, 14, 8, 3, 22].

3. PRODUCT DESIGNING

A characteristic feature of traditional, used in the 70's and 80's of the twentieth century way of organizing the design work was big participation of manual work, i.e. design ideas were manually transferred to the paper by successively drawn sketches and illustrations of particular machines' elements, devices or subassemblies and assemblies. On the basis of these drawings strength calculations of designed constructions, which aim was preliminary determination and selection of materials have been made. After the development of design documentation, this documentation was passed to technological department, where cost calculation of product and analysis of the possibility of its manufacturing using owned

machinery were done. The next step was designing the manufacturing processes for individual parts using the available resources of the enterprise [35, 9, 11]. More and more often the organization of the design work changes. Customer more frequently takes part in this process.

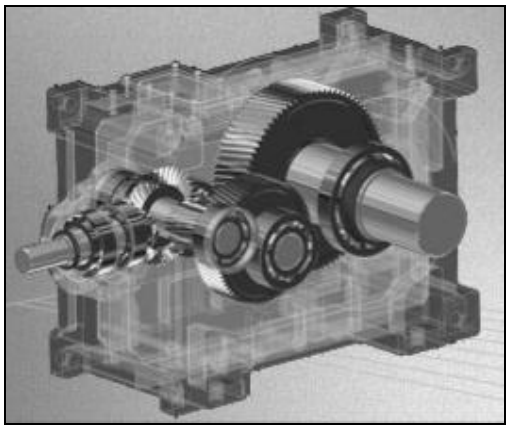

Fig. 2. The 3D model of helical-bevel reducer BH [32]

In the vast number of enterprises, which create design projects CAD systems are standards. Besides the possibility of drawing on the plan, first of all, they give the ability of designing and creating the 3D model in virtual space (Fig. 2) [8, 19, 14]. Traditionally in the superficial design building the model of newly designed object in order to exact fit subassemblies and assemblies, which were supposed to be placed inside the model was necessary. CAD systems enable generating a 3D model on a computer screen and realization of analogical operations without building such a model in practice [21]. For this purpose numeric entry model surface, generating a spatial grid, in which every spot inside the model is clearly, geometrically defined is used. This function enables precise fitting components of the model by unequivocal downloading the design data from a spatial model of the product [35, 14].

The effects of changes in the organization of design work, resulting from the application of computer support are reducing labour intensity of work and shorter product designing. Owing to new tools it is possible to control progress in the designers' works and to apply changes. Not without significance is also synergy effect in the teamwork, the designers have stopped working in solitude, often not seeing the results of their work. Computer technology gives the ability of simultaneous working on the product and evaluating the effects of own work on a virtual model of a new product. Also applying changes is much easier and it involves the modifying of the drawing in electronic form, and then printing or sending it in electronic

form to production department. By visualizing 3D model manufacturability of product becomes much simpler. With having a model it is easier to check the possibility of manufacturing the machines' elements. Additionally model can form the basis to automatic generation of CNC program [35, 30, 32, 3].

4. DESIGNING OF MANUFACTURING PROCESSES

Nowadays designing of manufacturing process is supported by IT systems. An important role in this process is played by CAPP (*Computer Aided Process Planning*) systems. CAPP systems are the connecting elements between CAD systems and CAM systems, providing database and graphical representation of the manufacturing process. CAPP systems can be separate applications (eg. Sysklass) or they can be modules of ERP systems [22, 3].

The concept of a Sysklass computer system is based on creating opportunities of as precisely as possible identifying relevant parameters of any object which is the subject of production. On the basis of specified by the identification information, system can generate certain technical solution, feasible to apply in given production conditions. The effectiveness of the identification provides classifier (Fig. 3) based on a combination of methods of shape and parameters of objects recognition, construction features and element's properties database and data connected with manufacturing process. Sysklass has parts database of the firm base and standard norms clearly arranged in graphic classification system with possibility of quick searching based on shape similarity and properties defined by user. Such capabilities are particularly important in SME, which use unit and small batch production [34, 21].

5. DESIGNING THE ORGANIZATION OF MANUFACTURING

5.1. Modern methods and techniques of designing the organization of manufacturing

The technical progress, development of information systems in the twenty-first century also cause changes in the organization of the manufacturing process. In their offer many SME have high-variety products, customized to customer's needs. This kind of requirements intensify need for reducing to minimum time and cost of designing the manufacturing processes. In this context, particular importance has the term of "Digital Factory" [8, 20]. The "Digital Factory" is seen as the planning instrument of the future. A large part of the factory planning, production- and product-planning is already supported by digital tools. These various planning phases are not integrated and thus are generally carried out in isolation. The goal is to achieve a holistic

planning, evaluation and continuous improvement of all significant processes and resources in the factory in connection with the product. All elements within the production should be modelled during planning by means of computer-supported methods, in such a way that the physical manufacturing of the product meets all quality, time and costs goals.

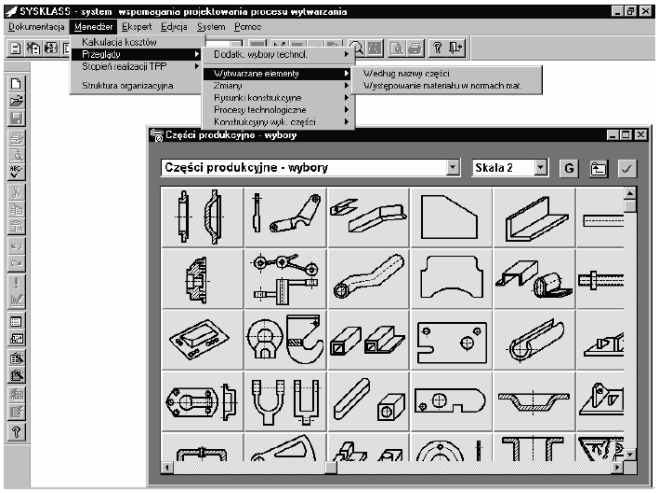

Fig. 3 Graphical classifier Sysklass [34]

The computer-supported models within the Digital Factory must document and visualize all the elements of the future factory as well as describe their interplay. Only when the digital product has successfully passed through the Digital Factory, the product is released into the real factory [8, 20]. "Digital Factory" technologies enable complex modelling and simulation through virtualization of processes. Methods and techniques of "Digital Factory", due to the cost find use in big corporations [20, 26]. However, it is expected, that in the future this kind of designing will be applied in SME. One of the major problems connected with organization the manufacturing process using tools of digital factory is problem with data acquisition. The development of laser technology has initiated the gradual emergence of scanners making quick acquisition of point clouds and its record in a form that allows further processing. Now, in the field of non-contact measurement of laser beam techniques, a whole range of devices, varied due to the accuracy and size of the scanned object is offered. While the acquisition of information and data from measurements performed using 3D scanners does not cause considerable difficulties, processing received by this method point clouds – does. Although the manufacturers of laser scanning equipment give customer IT programs, but usually it is used only for integration of data sets from different measuring stations and visualization of received cloud [20, 21].

The use of 3D scanners enables performance of virtualization of production systems before the designing of real system. After creating a virtual model of the production system simulation analysis using a three-dimensional applications can be carried out. An example of this type of tool is Delmia system or Technomatix system by Siemens. DELMIA Digital Solutions allow manufacturing organizations to design and visualize the entire manufacturing process for digitally specified product before implementation it to production. They are closely integrated with the CATIA design solutions, and also with ENOVIA and SmarTeam used to data management and to teamwork and therefore they provide significant benefits for customers, who implement PLM [6].

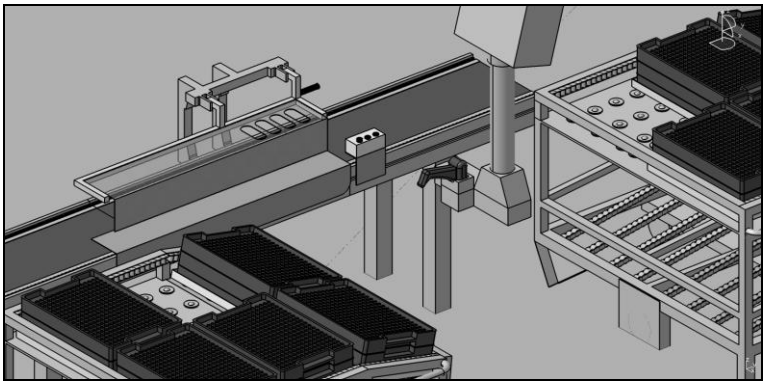

Fig. 4. Simulation of the assembling line [10]

Figure 4 shows an example of digitalized assembling line. Virtualization of workstations of one of the enterprises in the Bielsko-Biala region was created after the 3D scanning and transferring data to environment of Delmia software. After building a model of workstations , simulation of the manufacturing process in a virtual environment was done.

Above project was realized in "Polish-Slovak Cross-Border Networks of Innovation and New Technologies", co-funded by the European Union (European Regional Development Fund) [10].

5.2. Designing organization of manufacturing in conditions of unit and small batch production

In the processes of the organization and management of production most of manufacturing enterprises use in practice ERP systems. Using this kind of systems under current market conditions in the traditional form often becomes (is) insufficient. Traditional areas of application of such systems like finances, materials management have to be significantly expanded in the field of production management. The current market situation forces companies to

shortening manufacturing cycles of variant production, manufactured in ever smaller batches and at the same time to reducing costs and cutting time of availability of products. The answer to these requirements is change of machine park, organization and techniques of manufacturing as well as inclusion in the decision making process information systems [21]. The most important change in the ERP systems is starting treating them not, as the target applications, self-operating, but as the intermediate layer, enabling operation of management support systems in the area of operational management production. These systems have became more open. They enable superstructure of dedicated (customized) solutions on the universal solutions, specific for individual companies. The new quality is supporting decision at the operational level (in the) "on line" [24, 25].

So far in conditions of unit and small batch production often only one variant of the manufacturing process has been designed. Currently this approach is not enough. Due to the variable nature of the availability of resources it is necessary to separate organizational preparation of production in two stages. In the first stage – static, database of the available variants of the manufacturing process is created. In the second stage, at the operational level, from the available process variants optimal variant, which takes into account the current availability of renewable and non-renewable resources is chosen.

6. SUMMARY

The requirements of today's customer, determine manufacturing systems. Strategies of small and medium enterprises are more and more often directed towards manufacturing customized products. At present manufacturing systems must be prepared to produce families of products in the shortest possible production cycle. In conditions of unit and small batch production information system to support management decision making process is in many cases insufficient This is result of both, the assumptions of management model and insufficiency of used algorithms. Large variability of the planning factors and variety of products have an impact on this situation. Because of labor consumption of building the model, the use in decision making process standard simulation methods is too expensive and can bring correct results too late. In the processes of the organization and management of production part of enterprises use ERP systems use in production practice. The use of this class of systems under current market conditions in the traditional form often becomes insufficient. The traditional application areas of this kind of systems as finance, materials management must be considerably expanded in the area of production management. The current market situation forces enterprises to shorten production cycles of variants products, manufactured in smaller batches and at the same time reducing costs and shortening time of availability of products. The answer to these requirements is a change of machine park, organization

and manufacturing techniques, and inclusion in decision making process IT systems. The most significant change in the area of ERP systems is to start treating them not as a target application, self-operating, but as an intermediate layer, enabling the operation of management support systems in the area of operational management of production. Systems of this class have become more open, enabling superstructure above universal solutions of dedicated solutions specific to individual enterprises. The new quality is decision support at the operational level in the "on line" mode. So far, in conditions of unit and small batch production often only one variant of the manufacturing process has been designed. This approach currently is not enough. Due to the dynamic nature of the availability of resources it is necessary to divide organizational preparation of manufacturing into two stages. In the first stage - static, a database of the available manufacturing process variants is created. This course of action with the use of computer system is not very expensive. In the second stage, at the operational level, from the available process variants, optimum variant, taking into account the current availability of reusable and consumable resources is chosen.

Because of the complexity of the issue and the fact that the coding method depends primarily on the specific conditions of the enterprise, the use of this classification under practical conditions faces serious difficulties. An alternative approach is the use of grouping requiring no coding, carried out in an automatic way not at the level of manufactured element, but at the level of organization of operations of the manufacturing process. The new method of approach also assumes the automatic generation of operations of manufacturing process considering the results of the dynamic grouping.

Both, carried out research and production practice have proved utilitarianism of the proposed solutions.

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